AMERICAN
RAILROAD JOURNAL,
AND
MECHANICS' MAGAZINE.

No. 6, Vol. IV. New Series. | MARCH 15, 1840. | Whole No. 354. Vol. X.

DESTRUCTION OF WOODEN BRIDGES BY ICE.—SUSPENSION BRIDGES.

The breaking up of the winter has caused a recurrence of a specie of accident which is far from being rare. We allude to the destruction of bridges by the combined force of a swollen stream and immense masses of ice. The liability to this kind of accident depends more upon the character of the stream nearer its source than at the location of the bridge itself. A river of any considerable size receiving the drainage of a large track of country, is of course apt to be speedily swollen by a sudden and heavy fall of rain or rapid thaw, and as one or the other of these circumstances are sure to accompany the breaking up of the ice, such streams must present locations badly adapted to ordinary wooden bridges. Shallow streams, from daming up the ice, are rather worse than others in this respect, yet they are the most frequently crossed by these insecure structures.

Bridges of a more durable construction, if not built in the most substantial manner, are likely to suffer from the same cause, if the water way has been too much diminished.

The proper substitute in such localities are *suspension bridges* of iron wire. These claim the preference of all others, whether we regard to economy of first cost, or their superior adaptation to the circumstances of the locality. Over a large portion of our country the character of the streams is altogether more favorable to this than any other specie of structure. The example of the new bridge at Fair Mount will, we hope, speedily be followed in many places.

For the American Railroad Journal and Mechanics' Magazine.

THEORY OF THE CRANK, WITH REFERENCE TO DE PAMBOUR'S MODE OF CALCULATING THE PROPELLING POWER OF A LOCOMOTIVE ENGINE.—BY JOHN A. ROEBLING, C. E.

The question, "*Is the change of a straight motion in to a rotary motion, attended with any loss of useful power or not?*" has been the subject of va-

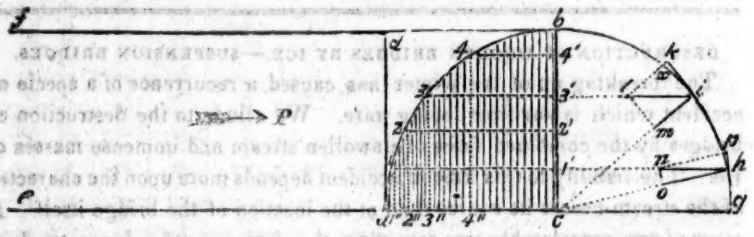
rious discussions among mathematicians, and has never been, to my knowledge, satisfactorily settled.

The *Crank*, by which that change of motion is effected, forms, in the present state of mechanics, a most conspicuous part of machinery, and the nature of its action should therefore be well understood.

The following demonstration, which the writer respectfully offers to the public, will prove, that if the amount of power actually expended is represented by 1, the application of the crank occasions a loss of useful effect equal to the expression, (π signifying the ratio of the circumference of the circle,)

$$1-\frac{\pi}{4}=0{\cdot}2146+$$

and, it is believed, that the principle of the crank may now be considered as fully established.



Let the above diagram, *a c b*, represent a crank, moving around the fixed shaft *c*, in the direction from *a* to *b*, and let the power applied be represented by the solid frame *e a d f*, moving in a straight course, corresponding to the direction *e c g*.

When the frame or the power is pressing against the crank at *a*, which point is commonly called the *dead point*, it is obvious, that the whole pressure is transferred to the centre of the shaft, *c*. The centre, being an immoveable point, will press with the same force back; therefore, the crank at *a*, will remain at rest, and will have no tendency whatever to move the shaft around the centre.

On the other hand, when the crank is at *b*, then the direction of the power will be vertical to the crank, and will press in the direction of a tangent; therefore, the full pressure is usefully applied at *b*, and no part of it is transferred to the centre.

Let us presume that the motive power is applied steadily and uniformly, moving the same distance, in the same space of time, and in the same direction.

As the full pressure acts at *b*, in the direction of a tangent, its effect with respect to the centre of motion will be as the radius *b c*, or, as the length of the crank; and if we represent the motive power by 1, then

1. *The effect of the crank or its momentum at b, will be = R, the radius of the quadrant.*

It is further clear, and an established principle in mechanics, that if the pressure of the moving power be uniformly the same, the amount of power, actually expended, will be in direct proportion to the distance the pressure has moved.

2. Therefore, when the power has moved from *a* to *c*, the amount of power or momentum, actually applied, is represented by the square *a c b d* $=R^2$; and if we denote the radius by 1, the unity will represent that value.

Let us now examine the effect of the power upon the crank at the intermediate points 1, 2, 3, 4, when moving from *a* towards *b*.

The direction of the pressure upon the crank at 1 will coincide with the line 11′ parallel to *a c*; therefore, the leverage of that pressure, with relation to the centre, must be $=1'c=11''$

At 2 the leverage of the crank is, $2'c=22''$

The leverage at 3 is $3'c=33''$

" " " 4 " $4'c=44''$

" " " *b* " $b\,c=R.$

The different leverage with which the pressure will act upon the crank to produce an useful result, for its motion around the centre, can therefore be represented by an indefinitely great number of ordinates, of the quadrant, as represented in the diagram, and the intermediate abscissas, corresponding to these ordinates, and forming infinitely small portions of the line *a c*, will represent the different extents of spaces through which the motive power has been travelling when acting upon the different levers.

The products of the different ordinates in their corresponding abscissas, will represent the different momenta, which have been produced upon the crank with relation to its motion around the centre, and the sum of these products will give us the whole amount of useful effect of the crank during one quarter revolution.

But the products of an ordinate and its abscissa is the area of the trapezoid formed by them, and the sum of these areas is equal to the area of the quadrant, therefore:

3. The total useful effect of the crank through one quadrant, is represented by the area of the quadrant, or

$$\frac{R^2\pi}{4}=\frac{1^2\times 3{\cdot}1416+}{4}=0{\cdot}7854+$$

4. The power applied being $R^2=1^2$, therefore the useful power lost is

$$\left(R^2-\frac{R^2\pi}{4}\right)=1-0{\cdot}7854+=0{\cdot}2146+$$

or equal to the area of the concave *a d b*.

ANOTHER DEMONSTRATION.

Suppose the crank moving from *g* to *b* and passing the points *h* and *i*. We may represent the pressure upon the crank at these points by the lines *h n* and *i l*. Now the pressure *i l* can be resolved into the two pressures *i m*

and $i\,k$, at right angles to each other, and forming sides of the parallelogram of forces $i\,k\,l\,m$. The pressure $i\,m$ being directed to the centre, will be useless for the motion of the crank. The pressure $i\,k$, in the direction of the tangent, is the only useful pressure, resulting for the motion of the crank.

The momentum of the crank at i is therefore $= i\,k \times i\,c = i\,k \times R$.

Likewise is the momentum at $h = h\,p \times h\,c = h\,p \times R$,

and so in all other points.

The triangles $i\,k\,l$ and $i\,l\,m$, are similar to the triangle $i\,c\,3'$, therefore

$$l\,i : i\,k :: c\,i : c\,3' :: R : c\,3' :: R : 3''\,3$$

and also,

$$n\,h : h\,p :: c\,h : c\,1' :: R : c\,1' :: R : 1''\,1$$

From this follows, that, if we represent the actual pressure of the moving power by R, then the useful tangential pressures, resulting for the motion of the crank at the different points $h\,i$, will be to the actual pressure as the ordinates $1''\,1$, $3''\,3$ are to the radius R.

We can further represent the amount of power actually expended at each of the different points h, i, by multiplying the pressure R, by an infinitely small extent of the line $c\,g$.

The useful momenta of the tangential forces, resulting for the motion of the crank, will therefore be obtained by multiplying the different ordinates with the same differential extent of $c\,g$. But these differentials are the abscissas belonging to the ordinates, and their aggregate products are represented by the area of the quadrant, therefore;

The useful effect of the Crank is equal to the area of the quadrant, if the power actually employed be equal to the square of the Radius.

The distance the crank travels is equal to the circumference $a\,b$ of the quadrant, for the same space of time in which the power applied moves from a to c.

5. Therefore, the travel of the piston is to the travel of the crank, as is the radius to the circumference of the quadrant; or as the stroke to half the circumference of the circle; or,

$$R : \frac{2R\pi}{4} = 1 : \frac{\pi}{2} = 2 : 3{\cdot}1416 + = 1 : 1{\cdot}5708 +.$$

Since the whole useful effect of the crank during one quarter revolution is equal to the area of the quadrant, we shall find the *average* force which carries the crank around by dividing the effect by the extent of the travel. Therefore

6. $$\frac{R^2\pi}{4} : \frac{2R\pi}{4} = \tfrac{1}{2}R = \tfrac{1}{2}P$$

is the expression for the average force: *or the average useful pressure of the crank is equal to one-half of the pressure applied.*

All the conclusions we have arrived at with respect to the crank, will apply as well to a cylinder, the radius of which is equal to the length of the crank, or the diameter of which is equal to the stroke of the piston.

If we examine the action of the crank by the *principle of virtual velocities*, according to which, the *effect produced*, should be equal to the *power applied*, and we denote the pressure of the power by P, its velocity by v, the useful propelling pressure of the crank by p' and its velocity by V, then the following equations should be correct:

$$P \times v = p' \times v$$

and by substituting for v its value R, and for V its value $\frac{1}{2} R \pi$ we have

$$P \times R = p' \times \tfrac{1}{2} R \pi$$

or,
$$p' = \frac{2}{\pi} P.$$

If we denote the correct pressure of the crank by p, we have according to No. 6,

$$p = \tfrac{1}{2} P$$

7. Therefore,

$$p : p' :: \tfrac{1}{2} P : \frac{2}{\pi} p :: \tfrac{1}{2} : \frac{2}{\pi} :: \frac{3{\cdot}1416 +}{4} : 1$$

or,
$$p : p' :: 0{\cdot}7854 : 1.$$

The law of *virtual velocities* gives therefore the propelling power of the crank 0·2146 + too great.

When a wheel is connected with the shaft of the crank, then the propelling power of the wheel is to the propelling power of the crank, as is the diameter of the crank, or the stroke of the piston, to the diameter of the wheel.

Let L = the stroke of the piston, and D = the diameter of the wheel, and P = the pressure of the piston, then is

8. The power of the wheel $= \frac{1}{2} P \times \frac{L}{D} = \frac{P L}{2 D}$

Formula for calculating the propelling power of a Locomotive Engine.

According to the principle of virtual velocities, the expression

$$\frac{2}{\pi} P$$

gives the propelling power of the crank, and applying this to the action of the wheel, we have, according to No. 8,

$$\frac{2}{\pi} P \times \frac{L}{D} = \frac{2 P L}{\pi D}$$

as the value of the propelling power of the wheel.

Now let d be the diameter of the piston, π the ratio of the circumference, then $\frac{1}{4} \pi d^2$, will be the area of one of the pistons. Let p represent the effective pressure of the piston in pounds per square inch, all other dimensions being given in inches, then $\frac{1}{4} \pi d^2 p$ will be the value of the total pressure of the two pistons.

By substituting this expression for P in the above formula, we have

$$\frac{2}{\pi} \times \tfrac{1}{2} \pi d^2 p \times \frac{L}{D} = \frac{d^2 p L}{D}$$

as the value of the propelling power of the engine, expressed in pounds.

This formula corresponds exactly with that offered by De Pambour, in his work on Locomotive Engines, (see Am. edition, pp. 109, 110.) But we have proved that the principle of virtual velocities, gives the effect 0·2146 + too great.

The correct expression for the propelling power of a wheel is according to No. 8,

$$\frac{PL}{2D}$$

by substituting for P its value $\frac{1}{2}\pi d^2 p$ we get

$$9. \quad \frac{\frac{1}{2}\pi d^2 p \times L}{2D} = \frac{\pi d^2 p L}{4D}$$

which is the correct formula for the propelling power of a Locomotive Engine, allowing only $\frac{\pi}{4}$ or 0·7854 + of the power, produced by De Pambour's formula.

Example.

Let $P = 50$ lbs. per square inch, or 7,200 lbs. per square foot, $L = 1{\cdot}5$, $d = 1$, $D = 5$. By substituting these values in the correct formula,

$$\frac{\pi d^2 p L}{4D}$$

we have

$$\frac{3{\cdot}14 + \times 1^2 \times 7{,}200 \times 1{\cdot}5}{4 \times 5} = 1695{\cdot}6 \text{ lb.}$$

as the propelling power of the engine, leaving all other considerations out of view.

De Pambour's formula,

$$\frac{d^2 p L}{D}$$

will produce

$$\frac{1^2 \times 7{,}200 = 1{\cdot}5}{5} = 2160 \text{ lbs.}$$

for the propelling power of the engine.

Now it is,

$$2{,}160 : 1{,}695{\cdot}6 :: 1 : 0{\cdot}7854 + .$$

Or De Pambour's formula gives the power nearly one-fourth too great.

De Pambour in his new publication on the Steam Engine, speaks of the great discrepancy between the theoretical and practical effect of Locomotive Engines, and he appears to acknowledge that the old formulas are insufficient. This distinguished Engineer presumes that the main cause of the error is to be found in the reduction of the pressure of the steam in the cylinders. There are, however, strong reasons to believe that this is not the case, if we take the evaporating power of the engine as the measure of its power, as we should do. One great loss of effect, is owing to

the use of the crank, as has been proved above, conclusively. We hope to be able to ascertain the amount of loss arising from other causes, particularly from the reaction of the waste steam, and may at some future period offer formulas which will very nearly agree with practice.

It remains yet to account for the loss of useful effect attending the use of the crank, or the change from a straight to a rotary motion, generally.

It appears that the law of virtual velocities is only applicable to analagous motions, with respect to actual and useful effect. Rotary motions and straight motions differ in their nature totally; they cannot be compared directly by that law.

The philosophical principle—*what matter is in existence cannot be lost, nor destroyed, but can only be changed in form and space,*—appears to be a grand universal law, rendering the existence of the Universe itself, permanent, and independent of time.

This principle, the truth of which will force itself upon the mind, by a concatenation of rigid deductions, must hold out in all cases, and therefore also in the case before us, where matter is brought into action to produce a mechanical effect. The laws of mechanics cannot be in contradiction to an universal law.

If therefore we cannot account for the loss of power in any way, we have strong reasons to doubt the accuracy of a demonstration which is to prove that loss of power.

On the other hand, no law has been established yet, to prove that the whole amount of power applied, can be made available for all purposes for which we want it, leaving of course friction out of view, and other circumstantial causes of loss.

In the case before us, let us suppose the tangential pressure *k i*, (see diagram,) is applied to the crank. If the impulse which the point *i* receives in consequence of that pressure, was allowed to be developed for any *actual extent* of space, in the line of the tangent, which is the direction of the impulse, we would be authorised to compare the quadrant to a succession of inclined planes, and we could prove *no loss* of power. But the impulse which is ready to act in the point *i*, is not allowed to develope itself in the direction of its natural tendency for any actual extent of space, *without being checked.* And since an inclined plane coincides with a straight line, and a straight line is the result of a point moving through an *actual extent* of space, in a straight course, it follows, conclusively, that we cannot compare the circumference of the quadrant with a succession of inclined planes.

We have made these remarks, in order to object to any demonstration which treats the circumference of the quadrant as a succession of inclined planes.

The impulse of the crank, with relation to the centre, can therefore only be considered for single mathematical points in the circumference, as *k*, *i*, without even allowing an initial extent for the display of the tangential forces.

The motion of a crank is therefore to be compared to the motion of a mathematical point at at an uniform distance around a centre; and which motion is the result of the action of an infinite number of tangential motives, successively applied.

On the other hand, suppose the point i was allowed to follow the tangential impulse for some distance and arrived at k, then the full tangential power would have been developed in conformity with its natural disposition.

But, in the case before us, some power must be expended in constantly diverting the impulse from its natural course. And the line $k\,x$ will represent the amount of that power required to force the point k, back towards the centre, to make it move in the circumference of the circle.

We may therefore conclude, that the loss of effect is caused by the abstraction of power from the tangential forces in order to check their natural tendency and to make them conform with a circular motion.

For the American Railroad Journal and Mechanics' Magazine.

It is stated in a short editorial notice at the end of the Journal of 15th February, that "on examining the article in our last number, on Dr. Lardner's experiments, it appears that the writer has fallen into an error, which vitates much of his reasoning. The article was prepared in haste, and the writer is not at present in the city, but will doubtless make the necessary correction."

The writer avails himself of the first opportunity to make these corrections, premising, however, that all the *practical* views and conclusions in the article referred to are, in his opinion, substantially correct, and that he still considers Dr. Lardner to have "signally failed in his attempts to prove that the resistance of the atmosphere has been *underrated*, that the *frontage* is unimportant, and that the resistance increases as the *volume* of the train."

The general results of Dr. L. appeared so palpably erroneous, and it appeared so very easy to show that they were so, that the first part of the article was written without that caution and close examination which should be bestowed even on investigations of the very easiest kind. The assertion, that "the mere ratio of the height to the length of the plane and the velocity which gravity can generate on that plane, are not sufficient to determine the value of the resistances," (p. 73) has some truth when discussing the motion of a body *up* an inclined plane, but has no application in the present case—hence the remarks contained in pages 71, 72 and 73, even when correct in themselves, have little connection with the subject under discussion. When a body, left free to the action of gravity on an inclined plane, attains a uniform velocity, the power and resistance are necessarily in equilibrio and they may be represented by the weight of the body multiplied by the height and divided by the length of the plane. The same error occurs at page 80, where it is said, "Now, if on a plane of 1-89, the entire force of

gravity be absorbed in overcoming the resistance, as previously assumed by Dr. L., whence is derived the power, which, by carrying the train up the next plane, so very nearly compensates for the power expended in the descent of the first?"

It is here overlooked that the entire power is absorbed only, *at that velocity*, and that the compensating power of the gradients arises exclusively from variations in the speed. Again, at page 73, speaking of a mode of determining the resistance by observing the actual velocity at the foot of an inclined plane, then calculating the height due to this velocity and subtracting that from the entire height, it is hastily *assumed* that Dr. L. and Mr. Wood would consider the resistance as represented by the total height of the plane because they so estimate it, and very properly, when calculating the resistance at a *uniform* velocity. The two cases are, however, entirely dissimilar, hence there is nothing to justify any such supposition.

It was said that "the late experiments of Dr. Lardner fully confirm the views of Mr. Brunel," etc. It would be more correct to say *some* of the experiments, for many of them are utterly irreconcilable with each other, or with the daily experience of the Whiston plane, as Mr. Brunel positively asserts.

In addition to what was then said to substantiate these opinions, as well as to show the value of the ordinary modes of calculation, the following experiments of Dr. Lardner are examined.

Tables IV and V give the velocity of one coach (5·35 tons) on a plane of 1·89 as equal to 23·15 miles per hour, being the mean of three experiments.

Tables VI and VIII give the velocity of eight coaches (40·75 tons) on a plane of 1·177 as equal to 25·48 miles per hour, being the mean of four experiments.

Now, if the resistance were as the volume of the train, we should have only half the velocity on 1·177, instead of which it is actually greater than on 1·89. In this case then, by increasing the volume of the train 8 times we have diminished the resistance more than one half, or, in other words, a train of 8 coaches will descend an inclination of 30 feet per mile more rapidly than a single coach will run down an inclination of 60 feet per mile.

This great difference would, by the ordinary modes of calculation, be ascribed to the frontage, which is the same in both cases, and, supposing this equal to 50 square feet, we have, with the velocity of 25·48 miles per hour a resistance from the atmosphere $=50\times3{\cdot}25=162{\cdot}5$ lbs. Now, the total resistance was equal to 1·177 of the weight, or 12·65 lb. per ton; and $40{\cdot}75\times12{\cdot}65=515{\cdot}48$ lbs. equal to the entire resistance. Deduct from this the frontage 162·5 lbs. $+(40{\cdot}75\times5=)$ 203·75 lbs. for the friction and there remains 149·23 lbs for the resistance of the air to the other 7 coaches, or 4·26 lb. per ton. Now add 5 pounds for the friction, and we have lb. 9·26 per ton, for the traction of all except the first coach at a velocity

of 25·48 miles per hour. De Pambour estimated it at 8 lbs. with an average velocity of about 19 miles per hour, and if Mr. Brunel is correct in stating, (C. E. and A. J. p. 70, vol. 2,) "The passenger train, in descending this plane, with the steam shut off the engine, which then causes some considerable resistance, frequently acquires a very high velocity, exceeding forty miles rather than thirty miles per hour, and requiring the use of the brake," then is he fully justified in saying, (p. 70, ibid.) that calculations "if judiciously made, would give more correct results, though not nearly so large as the experiments before us; they would at least be free from several very serious sources of error."

On Dr. Lardner's hypothesis the resistances ought to be equal in the two cases and the difference of more than one half cannot be explained, whilst with the ordinary modes of calculation, it is easily and satisfactorily accounted for. With a large train, the resistance would have been still less, as the frontage is constant, besides which, it is possible that part of the resistance, that is, the "friction" of the air on the *sides* of the carriages, may not increase as the square of the velocity.

All calculations necessarily suppose an absolute calm, a rare occurrence, and in nearly every practical case it would be necessary to determine the force and direction of the wind, and make the requisite allowances. This would be attended with immense labor, and could hardly lead to any beneficial practical result, hence it is not likely to be undertaken by competent persons. As observed in the previous "remarks," the subject is more curious than useful, or even interesting," and, did the present state of the public works offer any thing more substantial to discuss, the writer would consider himself bound to apologize to the readers of the Journal for filling up so many pages with these "airy nothings."

New York, March 7, 1840. W. R. C

GREAT INCOME FROM A RAILWAY.—20 PER CENT. PER ANNUM.

We have had placed in our hands, the "Statement of the Directors relative to the *Syracuse and Utica Railroad*, to 1st Jan. 1840."

This road was commenced in 1838 and put in operation, the 3d of July 1839, at the following outlay of capital. The distance is 53¼ miles.

For land damages,	$71,245 42
For grading, fences and bridges,	322,552 67
For superstructure,	411,751 92
For buildings, coach, engine, wood and water houses,	30,445 65
For engine and shop tools, snow plough, etc.,	1,250 50
For 18 freight cars,	4,979 93
For engineering, including preliminary surveys,	35,294 38
For commissioners' department, and incidental expenses,	36,868 95
	914,389 42

Deduct to show cost of road, this sum, for iron and stock in-

cluded in the above, for repairs *on hand*,		20,500
		$893,889 42

The nett income for the first six months, is as follows.

The receipt from 3d July 1839 to 1st Jan. 1840 was from 48,483 through, and 34,053 way passengers,	121,972 55
Transportation of freight $850, U. S. mail $2,801 08,	2,651 08
	$125,623 63

The expenses of transportation account, are

For superintending, collecting and clerk hire,	$2,177 38	
For services of engineers, firemen, brakemen, and stations,	5,394 40	
For fuel for locomotives,	10,525 93	
For oil,	454 22	
For repairs and alteration of engines,	2,308 96	
For repairs of coaches, and oil for do.,	1,307 69	
For taxes assessed on road,	1,777 61	
For incidental to transportation,	1,973 87	
For repairs of roadway, watching track, clearing away snow, and sundry work on road,	7,037 06	
For incidental expenses, cattle killed, repairs on depot in Utica, and ⅓ths interest on cost of depot,	1,810 96	
		34,768 11
Nett receipts in 6 months, on outlay of $893,889		$90,855 52

Note.—"The payments on transportation acconut in December are more than the monthly average, from the fact that in this years disbursements are included the semi-annual expenses at Utica, and nearly all the taxes for the year."

"The locomotive with business trains have travelled 35,139 miles."—This corresponds in a striking manner, with the estimates made by the Chevalier de Gerstner, that it costs $1 per mile on an average for the expenses of the locomotive engine on a well regulated railway.

J. E. B.

REPORT OF THE CAMDEN AND AMBOY RAILROAD COMPANY.—ANNUAL REPORTS OF THE RAILROAD CORPORATIONS IN THE STATE OF MASSACHUSETTS, FOR 1839.

The perusal of these documents has afforded a most welcome confirmation of our opinion, made up from long continued observation, that railroads afford the safest and most profitable investment of money in the United States. The continued prosperity of complete and well managed roads, amid the most fearful commercial distress, affords the best evidence of the truth of our statement. Railroads must be made and must be used, and the greatest effect that "hard times" can have upon them will be a reduction of fare—accompanied by an immense increase of business.

It is well known that no public exposition of the affairs of the Camden and Amboy railroad, and Delaware and Raritan canal joint company, has ever yet been made until the present time. The whole line and its numerous appendages amounting in all to 92¼ miles of railroad, is now complete, and in successful operation, and the Directors now make a report containing a full exposition of all their doings, a description of the work and an inventory of all their property. This document likewise contains the monthly receipt and expenditure, from the commencement of business on the line, and several comparative tables. If we separate the receipt and expenses of the canal, it appears that the railroad has averaged a nett profit of about 11 per cent., since its opening—an interest superior to that yielded by any other mode of investment. There are many interesting deductions to be made from the facts given in this report, the consideration of which is reserved for another occasion. Before leaving it however, we may remark, that the influence of the present untoward state of affairs, manifests itself in a remarkable manner. It will be found, that in the last three years the receipts have been rather less than in 1836, the period of their maximum, while the expenses have greatly diminished since that time, and that the nett profit is still increasing.

The Annual Reports of the Railroad Corporations in Massachusetts, to the Legislature of that State, are succinct statements of the condition of the roads, and the amount of expense and income, made under oath, and therefore are to be considered as excellent authority. Some of the works are but just commenced, others are partly finished, while a few have been in operation for some time. The following are those which have declared dividends.

Boston and Lowell,	8	per cent.
Boston and Portland,	6	per cent.
Boston and Providence,	8	per cent.
Boston and Worcester,	6½	per cent.
Nashua and Lowel,	7	per cent.
Taunton Branch,	6	per cent.
Eastern, (incomplete,)	4¾	per cent.

It is to be remembered that on several of these works, heavy sums have been expended for large portions of the line which are as yet incomplete, and yet need but little further outlay to finish them. The dividend is therefore on a capital, part of which is not yet productive.

That such profits should be made upon roads in a portion of a single State, when bank, insurance and every other stock has depreciated, is most cheering to the friends of Internal Improvement, and to the public generally. It is an evidence that we have abundant resources within ourselves, and that we need railroads for their universal diffusion. It shows, too, that what is most necessary, is most profitable; thereby offering a sure inducement to the gradual and universal extension of railroads.

With such prospects we need not despair. Increase of skill and inge

nuity have assisted the present condition of affairs, in reducing the expense of labor; and railroad companies have only to conform to the times, by reducing their fares, and a corresponding increase of revenue will take place.

It is a gratifying fact that these are not isolated cases; the reports of all well managed railroads throughout the Union, present the same prospect of a stendily and safely increasing revenue.

The time has almost, if not quite arrived, when the subject of Internal Improvement is to be separated from its unjust association with the bubbles of the day. They have burst, yet it remains sound and strong in the favor of all sensible and intelligent men.

ACKNOWLEDGMENTS.—We are indebted to *J. E. Bloomfield, Esq.*, for a copy of the Report of the Camden and Amboy railroad.—To *Jno. M. Fessenden, Esq*, for the Annual Reports of the Railroad Corporations in the State of Massachusetts.—To *Charles Ellet, Esq.*, for a Report and Plan for a Wire Suspension Bridge, proposed to be constructed across the Mississippi river at St. Louis.

IRON CANAL BOATS.—The success of this class of boats in England, with the arrival of the Iron Steamboat at New Orleans from Pittsburg, (of a very light draught of water, carrying a great cargo,) has lead to the opinion, that iron canal boats, if used on the Erie canal, would double its capacity, and supercede the necessity of the enlargement. We trust that some of our enterprising forwarders will try the experiment. We are not fully acquainted with the cost of this kind of boats, but have been informed, that it will not exceed fifty per cent on the cost of the best Lake boats.

In Pennsylvania, with their mixed line of canals and railroads from Philadelphia to Pittsburg, they now use iron boats, divided into three parts.

The iron boat is carried into Market street, Philadelphia, on the return of the cars, at the Schuylkill canal they are hooked together, forming a complete boat, which afterwards passes the Allegany ridge, by ten inclined planes, when they again take the canal and river, to reach Pittsburg.

With this complicated system, they compete with us successfully for the early spring trade.

RECEIPTS ON THE HARLEM RAILROAD.

Fare for passengers for Feb. 1840,	$4,812 16
do. do. do. 1839,	$2,848 82
Showing an increase in the last month over the corresponding month of the previous year; being equal to sixty-nine per cent. increase.	$1,963 34
Fare from 1st to 8th March, inclusive, 1840,	$1,795 47
do. do. do. 1839,	857 76
Showing an increase for the last eight days, over the corresponding period of last year, of	$937 76

Equal to 110 per cent. increase.

The total receipts for fare for the year ending on the 1st of March, 1840 are $102,691 31; while the total expenses are about $80,000; and the interest upon the debt of the company is $17,500.

TABLE OF COST, RECEIPT, AND INCOME, ETC., COMPILED FROM THE "ANNUAL REPORTS OF THE RAILROAD CORPORATIONS IN THE STATE OF MASSACHUSETTS," IN USE IN 1839.

NAME.	Length of road.	Cost of road.	Cost of road per mile.	Repairs of cars and engines.	Repairs of road.	Repairs of cars & engine per mile.	Repairs of road per mile.	Fuel, oil, and incidental expenses.	Total expenses.	Total receipts.	Total from passengers.	Total from freight	Nett profit.	Nett per centage.	Div'd
Boston and Lowell	25¾	1,608,476	62,465	16,384	18,843	636	731	56,923	92,151	241,220	135,037	106,131	149,069	9¼	8
Boston & Providence	41	1,782,000	43,460	19,467	8,604	474	209	65,491	93,562	313,907	234,237	79,670	220,345	12⅓	8
Boston & Worcester	14½	1,799,255	40,433	25 198	18,035	564	405	83,151	126,384	231,807	122,496	109,311	105,413	6	6½
Eastern, (incomplete)	25	1,306,196	32,655	8,563	6,527	214	163	38,084	53,174	125,623	113,068	12,564	72.449	5½	4⅔
Taunton Branch	11	250.000	22,791	3 152	1,397	287	127	36,161	40,711	58,018	40,910	17,108	17,307	7	6
Nashua and Lowell	14¼	353,662	24.321	2.273	3.949	156	272	23,663	29,885	55,053	36,647	18,406	25,168	6½	
Total,	61	7,099,589	Cost of	6 roads	yielding	an inter	est of	8⅓	per	cent., or	say,	582,387	343,240	589,751	8⅓	

Messrs Editors, Gentlemen:—

At your request, I continue, in a condensed form, the table of Cost, Receipt, and Income, of the Massachusetts Railroads, completed and in use during the year 1839. The table gives the average cost per mile of repairs to cars and engines, as well as of the road. It is to be regretted that the several official reports to the Legislature (sworn to by the officers of the company,) do not give more in detail the several items, necessarily placed under the general head of "Salaries, fuel, oil and all incidental expenses." The comparison of the different roads, and their yearly management, would detect errors of the first importance, to the interest of the stockholders. By a reference to the table furnished the last year, published in your June number, page 327, it will be perceived, that the Boston and Lowell railroad in 1837, received $180,770, and expended $78,503. This year they expend $92,151, and received 241,220, repairs of road and cars, increased. With the Boston and Providence the difference in 1837 is greater, $156,238 was paid out for expenses, to receive $250,-882. This year $93,562, to receive $313,907—whilst the repairs to road, cars and engines have decreased, in about the ratio the Boston and Lowell railroad has increased their expenses in these two items. It should be noted, that the Boston and Providence company purchased the franchise of the Seekonk Co., also the Boston water power and a second track to Roxbury, out of their earnings, amounting

to $100,848. This decreased their dividend from 12½ per cent earned, to 8 per cent. The expenses on the Boston and Worcester has greatly increased, while their receipts are nearly the same (?). It appears that the six roads completed, have cost $7,099,589, and have yielded to the stockholders $589,751, equal to 8⅓ per cent. nett on the capital expended. If these roads were now to be constructed, they could be completed, for full 33 per cent less, they would yield an increase of 10 per cent, which would yearly increase. On the Camden and Amboy railroad, this is reported to be 11 per cent. per annum. With such facts, can there be a want of enterprise and capital in the city of New York, to complete a line of Railways *from this city* to Buffalo. J. E. B.

LE COUNT ON RAILWAYS.

(Continued from page 158.)

In the third case, the engine does not go down a plane, as above, but has to make its own curve through its weight, deflecting the rail. The necessity then of knowing the laws of deflection is such, that no idea can be formed of the effects these important matters will have on the economy of railroads; yet we have up to the present day positively no data to go upon, which will lead us at all near the truth; and railways are constructing, at a cost very little short of seven millions, without the means having been taken to put such essential points as these out of the pale of doubt and uncertainty, which could be done by a few well conducted experiments. We know, for example, that in an iron bar, if l = the half length, x = any variable distance, y = the corresponding depth, and Δ = the sine of the elementary deflection, the sum of the deflections when

$$x=l \text{ is } \int \frac{x^2}{y^3} \delta x \Delta$$

for a parallel bar, and

$$\int \frac{x^2 \delta x \Delta}{(a+bx)^3}$$

for a fish bellied rail, in which latter expression a= the least depth, and b= the difference of the depths divided by the half length.

In some cases, where we have good experiments, the mode by which they have been calculated, in order to generalize and render available their results, is inaccurate, and the effect may be shown by the following table, giving the deflection of the rails, with three tons' weight on the middle of them, each column deduced from the same set of experiments, differently computed, and varying to an enormous degree.

Length of bearing in inches.	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*
33	·024	·026	·03	·02357	·0272	·0286	·072	·0858
42	·037	·050	·06	·047	·0538	.0569	·111	·1707
45	·041	·063	·072	·056	·064	·068	·123	·204
57	·064	·122	·139	·108	·123	·131	·192	·393
60	·074	·150	·171	·1335	·153	·162	·222	·486
69	·082	·210	·241	·188	·216	·228	·246	·684

Column *a* gives the deflections at 3 tons, deduced from the experiments by the experimenter, except for the sixty-inch, which is derived from the

fifty-seven inch bearing. Column *b* gives the deflections derived from the formula given by the experimenter as the results of the same experiments. Column *c* gives the deflections from this formula, recomputed by another person. Column *d* gives the deflections computed from another formula given by the experimenter. Column *e* gives the deflections in column *d*, computed by another person. Column *f* gives the mean of columns *c* and *e*, which appears to be the best approximation we have. Column *g* and *h* give the deflections for 9 tons' weight, the first being derived from column *a*, and the second from column *f*, the difference in the longest bearing 69 inches, being nearly 3 to 1.

With this lamentable uncertainty in the data for a deduction of such importance as that of a deflection in the rails causing an engine to be constantly ascending an inclined plane, there is no hope of arriving at any commonly accurate results. For instance, if we take the bearing of 5 feet which Mr. Barlow gives, as occasioning the ascent of a plane of 1 in 1875 the deflection, with three tons' weight, being ·064, and substitute for ·064 the deflections in columns *a* to *f* successively, we have as follows:

	Deflection.	Consequent Planes.
By column *a*	·074	1 in 1621
" *b*	·150	1 in 800
" *c*	·171	1 in 702
" *d*	·1335	1 in 899
" *e*	·153	1 in 791
" *f*	·162	1 in 741

In which there is more than two and a half to one difference in the results, all of which are drawn from one set of experiments, whilst at the same time the probability is, that the planes ought to turn out less steep instead of being more so.

From the effects which arise in consequence of deflection, it will be well worth considering what advantages are derived from the use of felt under the chair. If the rail was perfectly stiff, then, when the engine came over a chair, and compressed the felt, it would afterwards have to go up an inclined plane, through the rail being depressed at the block it had just passed over; and this would continue to take place till the engine arrived towards the next block, when it would depress the rail again in a similar way, and thus its course would be continually up a partially rising plane, the assistance downwards being almost insensible.

But as every rail deflects more or less, the inclination produced by this cause acts just exactly in the opposite manner to that which takes place through the depression and spring of the felt; for whilst the wheel, from the effect of deflection in the rail, descends during its passage over the first half of the rail, and ascends while going over the second half, the effect which the compression and springing of the felt has upon it, is to make it ascend a plane during its passage of the first half, and to descend during the time it is going over the second half. The felt acting as a spring, however, is exceedingly questionable, although maintained by some persons. Its use will be found to consist more in giving a steady seat for the chair when the block is composed of hard stone, and offering a defence against the grating of the chair on the block, which will otherwise take place, producing a grinding, a loss of surface, and consequently a looseness, which, when once arrived at, rapidly increases.

From the above observations on the effects of inclined planes, we may see how desirable it is to have the blocks and sleepers placed in the most accurate manner, as respects uniformity of height. For we must recollect that in a three feet rail, a difference of one quarter of an inch in the height

of two adjacent blocks, or, more properly speaking, in the height of the basis of two adjacent chairs, converts that three feet of rail into an inclined plane, rising 1 in 144.

With respect to placing the blocks diagonally, this is a less stable position in the line of rails than when they are placed square, for the resistance of the ground to the sinking of the block, whether conceived to be similar to a collection of springs acting under the block, or a collection of weights acting above it, must in either case be referred to the centre of gravity of each half of the block, considering it as moved by the passing weights about a line drawn through its middle at right angles to the line of the rails; that is to say, in a block two feet square, and one foot thick, there are 12 inches in the direction of the rails, 24 inches across them, and 12 inches in depth, acting on each side the axis of motion when the block is laid square, the surface of each half being 288 inches. Now, any uniform effect on these 288 square inches drawn into the distance of their centre of gravity from the axis of motion, gives for the stability of each half 1728. Any uniform effect on the 288 inches of a diagonal half block will give a less number; for the distance of the centre of gravity from the axis of motion was 6 inches in the square block, but it will be only 5·65682 in the diagonal, being 1-3d the altitude of the triangle, and hence we have only 1629·16416 for the stability in the direction of the rails. The diagonal block will consequently have its maximum resistance to sinking at 45° from the line of the rails, or in the position where stability is least required. Circular blocks have been proposed in order to get equal resistance in all directions, but the gain would not be equal to the extra expense, and the stability, although a trifle more than that of the diagonal block in the line of the rails, is less than that of the square one; for the area, as before, being 567 square inches, $=\cdot 785398\ d^2$, and d being the diameter, we have $d=\sqrt{733\cdot 386}$ $=27\cdot 0811$, and the radius $=13\cdot 5405$, and as the arc is to the chord, so is $\frac{4}{3}$ radius to the distance of the centre of gravity from the centre, or $3\cdot 14159 \times 13\cdot 5405 : 27\cdot 0811 = 9.02703 : 5\cdot 74678$ inches, and $5\cdot 74678 \times 288 = 1655\cdot$ $=07264$ for the resistance.

We have experimented on the two positions of the blocks, and found that when placed diagonally, there was rather more resistance to lateral motion than when placed square, and they are more conveniently got at to repack in the former position than they are in the latter; but when placed as close as they ought to be, in order to form an economical road, the diagonal position is inadmissible.

THE CENTRAL GEORGIA RAILROAD.

On the first day of February last, one hundred miles of this road was opened for travelling. This is much more than could have been expected, and is what untiring labor alone could have accomplished. We believe the annals of railroad enterprise in the South afford no parallel to the amount of work which has been done on this road, with so slight means, during the same period of time. The chief engineer, L. O. Reynolds, Esq., and his associates, deserve great praise. Economy has been brought to bear on every point for the perfection of the road, while durability has never been lost sight of. As a resident of Savannah, whose abode, in cloud or sunshine, it will be for life, we feel proud of this undertaking—as a citizen of Georgia, we feel doubly proud, that in the teeth of all croaking, at least, one General Assembly of the State, lent its aid to its projection. But, with sorrow we say it, we feel also humiliated—nay, ashamed, that the last two or three Legislatures of Georgia seemed to have lost every vestage of that li-

beral—that patriotic feeling that should ever actuate them. Yes—they appeared to have forgotten that Georgia had a seaport—that Savannah existed, that the flourishing city of Macon and her wealthy merchants, annually bought and sold thousands of bales of our great staple, which for a long season of the year, are piled up for transportation, to the only real outlet for exports—Savannah. What! surely they should remember that no State in this Union has ever risen in the scale of prosperity, without the assistance of a liberal administration of the public revenue. We would wish to be understood as being opposed to every scheme for internal improvement, that cannot be proved to the understanding of the most humble capacity, as deserving of support from the public coffers—therefore, the Central Railroad, one hundred miles of which have been completed and which already pays a dividend to its stockholders, has our hearty support. It is emphatically a work of public utility, and must enrich our people. It can in no event be stayed; and we hope, for the credit of our State, that no man calling himself a Georgian, will be found to throw a pebble in the way, even though his utmost endeavor can never stop its triumphal progress. Onward it must and will go; then let all, with heart and hand, bid it God speed.

The freight of cotton is now quoted, as worth $4,50 per bale, to be conveyed from Macon to this city, by water. This fact alone is worth a thousand arguments. The planters who send their cotton to the Macon market—the merchants who purchase it—and all concerned, except the boat owners (and it is doubtful whether they should be excepted)—all feel this heavy tax, consequent on a low river. It is for them, then, to lend a helping hand to the Central railroad, that it may be aided at the next session of the legislature—that justice, though tardy, may come at last.—*Savannah Tellegraph.*

EXPERIMENTS ON THE POWER OF MEN. BY JOSHUA FIELD, V. P. INST. C. E., F. R. S.

In this paper are recorded the results of some experiments made to ascertain the working power of men with winches, as applied to cranes. The experiments were undertaken with a view of ascertaining the effect men can produce working at machines or cranes for short periods, as compared with the effect which they produce working continuously.

The apparatus, a crane of rough construction in ordinary use, and not prepared in any manner for the experiments, consisted of two wheels of 92 and 41 cogs, and two pinions of 11 and 10 cogs; the diameter of the barrel, measuring to the centre of the chain, was 11¾ inches, and the diameter of the handle 36 inches. The ratio of the weight to the power on this combination is 105 to 1.

The weight was raised in all cases through 16½ feet, and so proportioned in the different experiments as to give a resistance against the hands of the men of 10, 15, 20, 25, 30 and 35 lbs. *plus* the friction of the apparatus.

The resistance occasioned by the friction of the apparatus is a constant element in all machines, and of much the same amount in most cranes, and my object being to obtain some practical results on the power of men in raising weights on a system of machinery, I did not think it necessary to make any experiment for ascertaining the amount of this resistance in the present instance.

In the following table I have set down the statical resistance at the handle, the weight raised in each experiment, the time in which the weight was raised, and the remarks which were made at the time with respect to the men. A column also expressing the power or effect by the number of

pounds raised one foot high in one minute is added. It will be necessary to add a few words respecting the construction of this column.

In order to compare these experiments with each other, these results must be reduced to a common standard of comparison, and it is very convenient to express the results of such experiments by the pounds raised one foot high in one minute, this being the method of estimating horses' power.—The number is in each case obtained in the following manner. I will take the first experiment.

Here 1050 lbs. was raised 16½ feet high in 90″; this is equivalent to (1050 × 16·5 =) 17325 lbs. raised one foot high in 90″, which is equivalent to (17325 ÷ 1·5 =) 11550 lbs. raised one foot high in one minute. In this case then

the man's power = 11550.

The same calculations being pursued in the other cases, give the numbers constituting the last column of the following table.

No of experiment.	Statical resistance at handle.	Weight raised.	Time in seconds.	Time in minutes.	Remarks.	Man's power.
I	10	1050	90	1·5	Easily by a stout Englishman	11550
II	15	1575	135	2·25	Tolerably easily by the same man	11505
III	20	2100	120	2	Not easily by a sturdy Irishman	17325
IV	25	2625	150	2·5	With difficulty by a stout Eng'man	17329
V	30	3150	150	2·5	With difficulty by a London man	20790
VI	35	3675	132	2·2	With the utmost difficulty by a tall Irishman	27562
VII	....	.....	150	2·5	do. by a London man same as Experiment V.	24255
VIII	....	.....	170	2·83	With extreme labor by tall Irishm'n	21427
IX	....	.....	180	3	With very great exertion by a sturdy Irishman same as Ex. III	20212
X	....	.....	243	4·05	With utmost exertion by Welshm'n	15134
XI	....	.....	35	.....	Given up this time by an Irishm'n	.....

We may consider Experiment IV as giving a near approximation to the maximum power of a man for two minutes and a half; for in all the succeeding experiments the man was so exhausted as to be unable to let down the weight. The greatest effect produced was that in Experiment VI. This, when the friction of the machine is taken into the account, is fully equal to a horses' power, or 33,000 lbs. raised one foot high in one minute. Thus, it appears, that a very powerful man, exerting himself to the utmost for two minutes, comes up to the constant power of a horse, that is, the power which a horse can exert for eight hours per day.

Lambeth, May, 1826. JOSHUA FIELD.

Trans. Inst. C. E.

MOHAWK AND HUDSON RAILROAD RECEIPT FOR 1839.

Receipts from passengers,	$116,664 26
do do freight and U. S. mail, ($4688,)	33,848 82
	$150,513 08
Expenditures, for horse, locomotive and steam stationary power, including incidental expenses, (exclusive of $7000 interest on loan of $100,000 borrowed,)	68,055 27
Equal to near 7½ per cent. on $1,100,000,—cost of the road,	$81,457 81

This company is at last earning an income on the extravagant disbursements for its cost, which exceeds $70,000 per mile, over a sand plain, being three times what this road would now cost, as stationary power can be dispensed with—contemplated by the company. It was an *experimental* railroad. This with others, by which our citizens have suffered, has given them prejudices against railways.

This road now requires the combination of three powers, (over the short distance of 15 7-8 miles) to wit: horse, stationary and locomotive—yet, singular to relate, a report from the Canal Board of 1835, gravely imposed on the public, the assertion (*on the comparison they made of railways with canals*) that the actual *cost* of transporting a ton of goods, per mile, on a railway, was three and a half cents; and in proof, instanced the Mohawk and Hudson railway, without telling us that it costs more to operate on this short road, than it does on the Utica and Schenectady railroad, of nearly five times its length where steam power alone is used.

The errors of this report have retarded railroads in this State, and raised prejudices against them, that we trust will be done away with by the present Canal Board. This report carried the Black river and Genessee canals, where railroads whould even now be built, if the public interest had been consulted.

When we have facts daily presented to us, of the enormous loads drawn by the locomotive engines since its improvement, it is high time for the present legislature to call on the Canal Board, and their new engineers, to institute inquiries, *into the relative merits of railways and canals*, to do away with the impressions produced by past legislation. These errors derived from the reports of Charles F. Mercer, Esq., in Congress, and those presented to the public by our State engineers. Both parties adopted the arguments and errors of the English *Canal engineers*, opposed to railways, on the commencement of railroads—then supposed (in error) to injure and interfere with the canal investments, when the reverse has proved to be the fact, as the price of English stocks show.

We notice that the Camden and Amboy railroad carried over their road the last week 5000 barrels of flour, at 25 cents per barrel, from Philadelphia to this city, and are now contracting for large quantities at this rate. We have no doubt, and assert, that with suitable arrangements, they could carry freight to profit at 15 cents per barrel. From Wheeling on the Ohio, they are now sending flour via Pittsburg, over the Alleghany, by railways, at $1 75 per barrel. With facts of this kind, and the refusal, so far, to permit railways to carry freight on the lines of railroads parallel to to the Erie canal, [*during the whole year,*] it is no object to go to the expense for the winter, subject to pay to the State treasury, the same tolls as if carried on the Erie canal, it is time for us to ask, if the present legislature can justify themselves to their constituents, by expending $40,000,000 on the enlargement of the Erie canal, while they refuse all aid to private enterprize in constructing railways. They reverse—the order of the day has been, to make enterprize tributary, to pay the interest on a work, *that is behind the intelligence of the age.*

Our friends of the west, and on the line of the Erie canal, will agree with us in this position, if they will examine the question with candor. Let engineers who are not wedded to canals examine the subject, and we venture to assert, they will give it as their opinion, that a line of railway from Dunkirk and Buffalo to the Hudson, will supercede the necessity of *any enlargement* of the Erie canal for the present century. That, if cleared out to four feet, with double locks to Montezuma, it will be all the public will

require for cheap transportation and competition, with reduced rates of toll.—*Star.*

IMPROVED LOCOMOTIVE.—On Saturday last, we had the pleasure, in company with several scientific gentlemen of this place, of witnessing a new and improved locomotive engine, in full operation. The advantages derived from the improvement on this engine, are no doubt very important, and we have no hesitancy in predicting, that when once fully and practically developed, will be generally adapted not only to stationary, but to locomotive engines on our public roads. One essential improvement in the construction of this engine, is the saving of steam, which requires but one half the quantity and maintains the same power as that of an ordinary engine. We were particularly pleased with the neat and elegant finish of the engine, and certainly does much credit to the mechanical genius of the projector and builder, Col. Henry High, of this borough. We understand that a patent right has been secured, and that a thorough trial of its advantages will shortly be made on the Columbia railroad.—*Reading Democratic Press.*

TUNNEL THROUGH THE ALPS.—M. Vanino Volta, the engineer of Como, who, in conjunction with M. Bruschetti, of Milan, obtained in 1837, from the Austrian government, a privilege of fifty years for the construction of a railroad between Milan and Como, is now negotiating with the Swiss Cantons of Grisons and St. Gall, an enterprise which would vie in magnitude with the Thames Tunnel, viz., the piercing through the Grisons Alps. Impressed with the importance of the passage of the Splugen, and, at the same time, with the various obstacles which it presents, he thinks it possible to pierce through that mountain, and establish in the passage thus effected, a railroad, the northern portion of which would end, either at Wallenstadt, or even at Schomerken, on the Lake of Zurich, and the southern should be connected with the Como and Milan Railroad. M. Volta, reckoning that thirty years will be required to execute the works, demands an exclusive privilege of a hundred years, with liberty to establish companies, in order to procure funds, or to transfer privilege to other parties.

OF THE APPLICATION OF STEAM AS A MOVING POWER, CONSIDERED ESPECIALLY WITH REFERENCE TO THE ECONOMY OF ATMOSPHERIC AND HIGH PRESSURE STEAM. BY GEORGE HOLWORTHY PALMER, M. INST. C. E.

Although the question relative to the comparative power of the Cornish and other engines has engaged the attention of this Institution, (and doubtless that of every practical engineer,) still no conclusion has been arrived at satisfactorily explaining upon what principle, the duty of the former engines so far outstrips the best reported duty of the Watt engine. The difference is truly astounding, for it is officially asserted that the average duty of ten or twelve of the Cornish engines amounted to 70,000,000 lbs. of water raised one foot high by the expenditure of one bushel of coals; and in some instances, a result has been brought out so high as 100,000,000 lbs, and even 120,000,000 lbs. by the like expenditure of fuel. Even the 70,000,000 lbs. duty appears to me to be so wide of the mark, as compared with the best stated result of the Watt engine, (viz., 28,000,000 lbs.,) and the maximum effective power hitherto generally obtained by the consumption of one bushel of coals, that I am induced to address the Institution on the subject; and although the statement I herewith submit for consideration only furnishes presumptive evidence, that the statements of our Corn.

ish friends involve some error, the proof is in my mind so powerfully conclusive, that nothing short of the actual admeasurement or weighing of the water, stating the altitude such water is raised, together with the weight of fuel consumed, will induce me to believe otherwise than that the data on which the calculations have been based are in some respects erroneous.—Such is my conviction, on the evidence at present before me, and which I trust will on perusal clear me from the imputation of egotism.

I care not whether the steam applied as a motive power be what is termed atmospheric, or high pressure; whether it be worked expansively or otherwise; whether condensed in a vacuum or blown into the atmosphere —whether the engine be of the description technically denominated single, double or atmospheric; or in fact whether the steam be applied to any other description of apparatus, human ingenuity and wisdom may devise, even in the absense of *all* friction; in short, if all the moving parts of the engine were in equilibrio, and capable of being put into motion by the least appreciable amount of power; and neither the steam nor water meets with resistance in its passage through valves, cocks, pipes, &c., and the steam undergoes no change of density, elasticity, or temperature from the instant it is generated till it has performed its intended duty; supposing these physical impossibilities could be accomplished, I conceive that 70,000,000 lbs. of water cannot be raised one foot high, by the consumption of one bushel of the best Newcastle coals, weighing 84 lbs., unless more than one cubic foot of water of 40° F. can be converted into atmospheric, or high pressure steam, by the consumption of 7 lbs. of fuel.

From the discoveries of the illustrious Italiam Philosopher Torricelli we are all aware that the maximum pressure, or elasticity of the atmosphere, at the level of the sea, does not exceed a column of mercury 31 inches high, or that of water 35$\frac{1}{2}$ feet in altitude, which amounts to about 15 lbs. pressure upon every superficial inch of the earth's surface.

We know that one volume of distilled water will, when converted into atmospheric steam, (barometrical pressure 30 inches,) fill a space 1694 times greater than when in its liquid state, (temperature 40° F.,) supposing such steam is kept at the precise temperature and elasticity at which it was generated. We know also that the said steam, when reduced to its original temperature, (the atmospheric pressure being unchanged,) will assume instanter its original state and bulk, or occupy $\frac{1}{1694}$th of the cubic space which it occupied when in its gaseous form.

We have evidence also (founded on the most accurate experiments, and which are not likely to be surpassed by the decomposition of coal in the furnaces of steam engine boilers, with all the "jacketing" that may be applied, in order to avoid the loss of caloric by radiation from the boiler, cylinder, &c.,) that seven pounds of good bituminous coal is required (when the combustion of its inflammable matter is nearly perfected, when no excess of, or undecomposed atmospheric air escapes through the ignited fuel, and when the least quantity of radient caloric escapes from the steam generated) to convert one cubic foot, or 62$\frac{1}{2}$ lbs. avoirdupois, of distilled water from 40° F. to atmospheric steam, at an elasticity corresponding with a barometrical pressure of 30 inches.

From the aforesaid data I will show that nature cannot herself produce a result (in the absence of all friction as before premised) amounting to one half of what is stated to be the duty of some of the Cornish engines, if the authorities referred to can be relied on.

If, therefore, one cubic foot of water is convertible into atmospheric steam by the caloric evolved by the combustion of 7 lbs. of coal, 12 cubic feet of water would require, under like circumstances, 84 lbs., or one bushel of

coals. Now 12 cubic feet multiplied into 1694 cubic feet or volumes gives 20,328 cubic feet of steam, which amount represents the precise quantity of water which would occupy its place when such steam is reduced to the temperature of 40° F., and which we will suppose would rise 35 feet high which we are aware exceeds not only the average, but the maximum barometrical column. It therefore only remains to multiply the aforesaid 20,328 cubic feet into 62½ pounds, and that product by the assumed altitude the water is raised in a vacuum, viz., 35 feet when we shall have the maximum effect nature is capable of accomplishing, viz., 1,270,500 lbs. of water raised 35 feet high, or 44,467,500 lbs. one foot high, with one bushel of the best Newcastle coal.

Having shown the maximum effect that can be accomplished by the application of the atmospheric steam, generated by a given quantity of fuel, my next object will be to demonstrate that high pressure steam, when applied expansively, cannot produce so great an effect as atmospheric steam, thereby meaning to infer that no high pressure engine can perform the same amount of duty as a condensing engine, both consuming equal quantities of fuel. This is my deliberate opinion, founded on theoretical and practical experience, and which coincides with the opinion of almost every practical engineer whom I have consulted on this important subject. But what says the authority before refered to?—for in this as well as in the former question, just discussed, my arguments shall be drawn from the established laws of nature.

1st. That the sum of sensible and latent heat in steam is a constant quantity, viz., about 1172° F.

2ndly. That all matter, (steam, of course, included,) whether solid, liquid, or gaseous, from the most dense and refractory to the least ponderable, evolves caloric on compression, or increase of specific gravity, and absorbs caloric on dilatation, or when its specific gravity is diminished.

3rdly. To convert equal quantities of water of any assignable temperature, and under like pressure into steam of given temperature and elasticity, requires equal weights of fuel to be expended; but, although equal weights of water must absorb equal increments of caloric when atmospheric steam is generated, it does not follow that all the caloric absorbed in high pressure steam is exclusively supplied by the fuel expended. The law maintained is simply this, that the same causes produce the same effects.

4thly. That steam of two, three, or more atmospheres elasticity, is not composed of two three, or the like number of volumes of water contained in an equal volume of atmospheric steam, when generated under the same barometrical pressure, but contains proportionably less water as the pressure under which the steam is generated increases.

In proof of the foregoing theorems, I beg to adduce the following experiments and observations.

1st. If steam be blown through and condensed in a given weight of water of any previously determined temperature, until the said water arrives at, say, 212° F., the quantity or weight of water added by such condensation will be precisely the same, whether the steam employed be of atmospheric, double, treble, or more elasticity, thereby establishing the extraordinary fact, that all sensible caloric, exceeding 212° F., positively goes for nothing, it having become latent by dilatation. In this experiment, it is necessary to observe, that the steam condensed has lost no caloric by radiation till after such steam was converted into vapor, and the effect sought had been produced. How then a saving of fuel can arise by the use of high pressure steam worked expansively is to me an evident paradox, unless by some power utterly beyond my comprehension; the sensible caloric can

be prevented from becoming latent by dilatation, which, I need scarcely add, no power can accomplish.

Again, generate steam in a suitable apparatus at, say 500° F., and permit a jet of such steam to blow upon the bulb of a thermometer without the boiler; it will be observed, that the steam impinging thereon, registers a temperature below blood heat, (98° F.;) remove the lamp that kept up the aforesaid temperature of 500°, and let the jet of steam continue to play upon the bulb of the said thermometer till it ceases to blow from the boiler at which instant of time the thermometer within and without the boiler will indicate the same temperature, viz., 212° F. In this experiment, it is no more remarkable than true, that while the steam in the boiler is descending from 500° to 212°, that the steam blowing into the atmosphere is increasing in its temperature from 98° to 212°. Here then we have 402° of sensible caloric becoming latent by dilatation, thereby increasing the amount of latent heat in the steam of 500° from 672° to 960°, the quantity due to atmospheric steam; while in the steam of 98° there is 1074° of latent heat. As atmospheric steam can be applied without converting sensible into latent caloric and as the sensible caloric therein contained is of a maximum effective quantity, it follows that its application as a moving power, must, under every possible application, be more economical than high pressure steam worked expansively, on a comparison of the fuel expended in the two cases.

It remains to be explained why steam of 500° temperature, and of an elasticity equal to 44 atmospheres over and above the atmospheric pressure, denotes, when blown into the atmosphere, a temperature of 114° below that of atmospheric steam.

In one measure of steam of 45 atmospheres elasticity and of 500° temperature, there is considerably less water than is contained in atmospheric steam of 45 times its volume or cubic contents, consequently such steam, when expanded under atmospheric pressure, necessarily converts a greater portion of sensible into latent heat, than if the steam thus expanded had contained the quantity of water due to forty-five measures or volumes of steam generated under a barometrical pressure of 30 inches. Another portion of the sensible caloric lost or become latent, is due to the steam expanding beyond what its density and temperature would assign under atmospheric pressure; this result of the compressed atoms flying too far asunder is similar to that in which a spring of certain elasticity, when suddenly let go, recoils beyond its true position, being carried thither, by reason of the momentum acquired and due to its weight, elasticity and velocity; so great indeed is the effect produced by the two causes assigned, that steam of 45 atmospheres elasticity passes instantly, (when expanded under atmospheric pressure,) from the gaseous to the liquid form.

The second theorem admits of innumerable proofs, but a few examples will suffice to establish the fact, that change of specific gravity cannot possibly be effected without caloric being either given out or taken up; that is, either latent heat becoming sensible by diminution, or sensible heat becoming latent by increase of volume. Compress permanent gaseous matter, and in proportion to its increase of specific gravity will sensible caloric be evolved, let this gas cool down to the temperature of the apartment, and let the compressed gas suddenly expand to atmospheric elasticity, when the sensible caloric before evolved by compression will be instantly re-absorbed and become latent, thereby producing a diminution of temperature even sufficient to freeze water. This was a common experiment at the Portable Gas Works in this metropolis. In the Philosophical Tinder Box we can generate with a smart stroke of the hand, sufficient sensible caloric

from compressed atmospheric air to ignite Dutch tinder. Liquids as well as gaseous matter will by increase of their specific gravity also give out sensible caloric, as is witnessed by the admixture of about four measures of distilled water with one of concentrated sulphuric acid, when the compound will, in a few seconds, exceed the temperature of boiling water. The very familiar experiment of slacking concrete caustic lime by the application of water, and the caloric thereby evolved, is the necessary consequence of the water assuming the solid state. Solids also, as well as liquids and gaseous matter, are governed by the same law, for an expert smith will, by a few blows of a hammer upon a malleable piece of wrought iron, elicit sufficient sensible caloric to make it red hot, so as to explode gunpowder therewith. The caloric evolved is exclusively the result of the metal's increase of specific gravity by striking the iron at right angles, by which operation the cohesion of the atoms of metal are so destroyed by separation as to require welding before the experiment can be successfully repeated; not that the fractured iron receives a new supply of sensible caloric in a latent state by being heated in the fire, as has been asserted, but by reason of the shattered particles of metal being rendered in a fit state to receive the blows of the hammer without flying to pieces, which would be the case, but for the fact of the fractured metal being again united by the process of welding. Each atom of metal actually contains sufficient caloric in a latent state (when liberated by percussion or any other mode of concentrating the particles of metal) to destroy the metal's identity by converting it into a perfect oxide as is witnessed by the combustion of the particles of iron or steel abraded by the flint, in the act of striking a light, as it is termed. The late Mr. Wedgewood, to his astonishment, elicited caloric by the friction of two incombustible substances, viz., glass and stone; but he seems to have had no idea that this phenomenon was the result of compression or increase of specific gravity by the friction and abrasion of the matter thus acted upon. Of the latter case, we have the most striking proof in the following experiment, viz., that a cast iron bomb, when filled with water and subjected to an intense frigorific operation, does not assume the solid state (ice) till the cast iron shell is ruptured by the combined efforts of the metal contracting, and the water (in the aggregate) expanding, thereby overcoming the cohesion of the metal, when the shell bursts, and the water instantly becomes solid; at that instant caloric is evolved; and to show the beautiful harmonious working of nature in the chain of cause and effect, no evolution of caloric takes place till the water is frozen, thereby showing that a concentration of matter has taken place. The fact of water, in a concrete form, floating on water of the same temperature, is cited by philosophers as one of the exceptions to the general law—namely, that caloric is evolved with a diminution instead of an increase of specific gravity founded on the abstract fact, that ice, (and I may add, saline solutions) at the instant of crystallizing swim instead of sink. The cause of which phenomena should be sought for in the innumerable cells or spaces charged with air; or, in the buoyancy of those cells or air vessels in the aggregate more than compensating for the increase of specific gravity the water undergoes by congelation, thereby producing the paradox in question, viz., an evolution of caloric, and yet an apparent loss of specific gravity, judging from the abstract fact of the ice swimming upon water of the like temperature. We therefore learn the fact, that the water at the instant it assumes the solid form both contracts and expands; by the former, caloric is evolved, and by the latter, (not in each atom, but in the aggregate,) it floats upon water of its own temperature, not because the ice is specifically lighter than the water, but by reason of air cells or vacuities before referred to.

The experiment of Perkins, whereby a soft malleable wrought iron plate, revolving at an immense velocity, not only cuts its way into a file applied thereto, but elicits such a coruscated blaze by the combustion of the steel and iron abraded, as to astonish even the scientific beholder, furnishes evidence of the result of the compound operation of friction, and consequent increase of specific gravity of the metals abraded. Not the least apparently astonishing part of this performance is, that of the hard steel file being cut by the comparatively soft malleable iron plate; but all astonishment will, no doubt, cease on remembering that the density or hardness of the file as compared with that of the revolving plate, is in a much less ratio than the area or the rubbing part of the latter, as compared to the area of that part of the file coming in contact or rubbed therewith. For example, the file is probably not twice as hard as the revolving plate, whereas the grinding surface of the latter probably exceeds the area of the file ground, one hundred times; hence the wear of the file is inevitable. I cannot doubt but that the particles of wrought iron abraded and excited into combustion, greatly exceed in number the atoms of steel. This is not discovable on superficial observation by reason of the great diameter and inreased surface of the revolving plate, viewed in connection with the surface or quantity of the file detached in the operation.

That a soft elastic substance will wear away more dense and inelastic matter, is verified by the well known fact that the cuticle or scarf skin of the hand wears away both cast and wrought metal hand rails; and what appears still more astonishing, but is nevertheless well authenticated, is that of the marble steps leading to some favorite saint, having been worn quite hollow by the friction of the naked feet and knees of pious devotees.

The third theorem partakes of positive and negative qualities, for each abstractedly considered neutralizes the other; in fact, the question admits of no other than a false solution, unless the intermediate cause and effects, dilatation and the sensible caloric thereby becoming latent, form components of the question, viz., that high pressure steam, when applied expansively, as a motive power, is less economical than atmospheric steam when not permitted to expand till the piston has completed its stroke. There certainly appears, at first view, something very peculiar about highly elastic steam when expansively applied, for the fuel saved is positively just so much fuel lost; paradoxical as it may appear, it is really no paradox, but is in strict accordance with the working of nature's laws; and I sincerely wish that all other supposed paradoxes could be as readily cleared up.

In practice, we observe that every additional atmosphere's elasticity steam is generated at, the time is shorter than was occupied in generating the previous atmosphere; even when equal quantities of combustible matter are decomposed, or equal increments of caloric are evolved in equal periods of time; in this case the saving of fuel accruing will be in the exact ratio to the time saved, and is exclusively the result of steam of a given number of atmospheres elasticity containing less water than is contained in the same number of volumes of atmospheric steam, the inevitable consequence of latent heat being evolved in a sensible state as the steam's density increases; which caloric, of course, increases the steam's elasticity, and is therefore the precise measure or amount of fuel saved in generating highly elastic steam, but is unfortunately lost when such steam (as will be hereinafter shown,) is applied expansively. Atmospheric steam registers a temperature of 212°, steam of ten atmospheres elasticity of 358°, twenty of 418°, thirty of 457°, forty of 486°, and that of fifty atmospheres elasticity a temperature of 510°. Here then the quantity of sensible caloric in each atom of steam of 510° temperature produces a power infinitely great-

er than that of steam in equilibrio with the atmosphere, which when condensed in order to gain the atmospheric effect, is only one-fiftieth part of the power of steam at 510° temperature, although it is barely 2½ times less temperature than atmospheric steam. Here then is evidence of the saving of fuel, or what is the same thing, demonstration of an immense increase of power obtained by the expenditure of a given quantity of fuel; but what it amounts to in practice may readily be inferred from what has previously been advanced relative to the change of specific gravity. If less fuel is expended to generate steam of every successive atmospheres elasticity—(which every accurate experimenter knows to be the fact,) it necessarily follows that every succeeding atmosphere generated, contains a less quantity of water than the preceding atmosphere or volume.

1st. Because equal quantities of caloric are required to convert equal quantities of water into steam, supposing the steam generated to be atmospheric.

2ndly. Because the steam cannot increase in its specific gravity and elastic force, without converting a portion of sensible into latent caloric, and this is the intermediate cause and effect that is lost sight of; and

3dly. Because the latent caloric becoming sensible, necessarily gives an increased elasticity to the steam through which it is diffused, and the increase of elasticity thereby produced is (as before stated) the precise amount of fuel, or caloric, saved in generating high pressure steam as compared with the generation of a like volume of atmospheric steam.

It must be particularly borne in mind, that the fuel saved refers only to the steam's generation (as before stated,) for it is one thing to generate high pressure steam, and another to apply expansively the said steam as a motive power; unless the opponents to the doctrine are prepared to prove that high pressure steam, by dilatation or diminution of specific gravity, does not convert sensible into latent caloric; or that they are further prepared to demonstrate, (upon Mr. Woolf's erroneous principle,) that the second dose of sensible caloric gives an elastic force to the expanded steam, (when maintained at the temperature such steam was generated at,) equal to the atmospheric pressure.

Steam at or above 212° temperature is as much a permanent gas as atmospheric air, unless it be subjected to a pressure exceeding its own elastic force and the trmperature due to such elasticity; in which case it would be converted into the liquid state. Again, steam is known to be governed by the same law as permanent gases, (relating to the law of elastity,) when dosed with caloric, over and above the temperature at which it was evolved. It therefore remains to show, (if not already proved,) that the quantity of sensible caloric lost by working high pressure steam expansively, can never be compensated for by saturating snch steam with a second dose of caloric.

Philadelphia and Columbia Railroad.—Collector's office, Philadelphia, Feb. 28th, 1840.—The following shows the Collection at this office:

	Railway.	M. Power.	Total.
Amount as per last report,	14,574 74½	15,085 84½	29,660 59
Do. week ending Feb. 27,	746 82	925 01	1,671 83
Whole amt. since Oct. 31, 1839,	$15,321 56½	16,010 85½	31,332 42

A. B. Cummings, Collector.

Railroad Receipts.—The income from passengers alone on the Syracuse and Utica railroad, from July 3d to November 30th, five months, was

$115,301. The cost of the road was $911,959, so that it yielded about eight per cent. upon the cost of construction, or about nineteen per cent. per annum. The Syracuse and Utica railroad is parallel with the great Erie canal, and being owned by a company, is prohibited from carrying freight except when the canal is closed.

EIGHTH ANNUAL REPORT OF THE BOSTON AND LOWELL RAILROAD CORPORATION.

To the Honorable the Legislature of the Commonwealth of Massachusetts:

The directors of the Boston and Lowell railroad Corporation, do hereby make their eighth annual report of their acts and doings, receipts and expenditures, under their act of incorporation.

The total amount of capital paid in, is	$1,650,000 00
The amount expended during the past year, exclusive of amount spent and charged to the cost of the road, is	
For repairs on the road, including repairs on bridges and some improvement in drainage,	18,843 09
For repairs on engines and cars,	16,384 54
For fuel, oil, salaries, wages, and all other miscellaneous expenses,	56,923 81
	$92,151 44
The amount received during the past year, is	
For transporting passengers between Boston and Lowell,	119,923 30
" " merchandize, and U. S. mail,	101,745 55
" " passengers for the Boston and and Portland railroad corporation over our road,	15,114 15
" " merchandize for the Boston and Portland railroad corporation over our road,	4,436 04
	$241,219 94

The amount divided during the past year, is $126,000, being two dividends of four per cent. each, one on a capital of 1,500,000, the other on a capital of $1,650,000.

Since the last annual report, there has been expended towards the completion of the road, depots, and appurtenances,	$32,812 71
Whole amount expended on the cost of the road and appurtenances at the time of the last annual report,	1,575,663 50
Whole cost of the road, to November 30th, 1839,	$1,608,476 21
Balance of capital unexpended,	41,523 79
	$1,650,000 00

A portion of the second track has been in daily use for more than a year. Iron rails have been ordered, and other preparations made for its continuation towards Lowell the coming summer.

All which is respectfully submitted,

P. T. Jackson, Wm. Appleton, Joseph Tilden, Geo. W. Lyman, John Briant, *Directors.*

FIFTH ANNUAL REPORT OF THE BOSTON AND PORTLAND RAILROAD CORPORPTION.

To the Honorable Legislature of the Commonwealth of Massachusetts:

The directars of the Boston and Portland railroad corporation do hereby make their fifth annual report "of their acts and doings, receipts and expenditures," under their act of incorporation.

Soon after their last annual report was submitted to the legislature, the directors proceeded to make provision for the extension of their road from

its temporary termination in Bradford, to the line of the State of New Hampshire, there to connect with the Boston and Maine railroad, then and still in progress of construction through that State to the line of the State of Maine.

They proceeded to the erection of a bridge, of the most approved construction for stability and permanence, and 850 feet in length over Merrimac river.

The said bridge was so nearly completed, as to be ready to accommodate the business of the road in the early part of December last; and the remaining portion of the Boston and Portland railroad, together with about nine miles of the New Hampshire portion of the same line was opened for the accommodation of the public on the first of the present month.

The entire cost of the addition to the Boston and Portland railroad, including the bridge, depot buildings in Haverhill, land for the accommodation of the same, will not exceed the estimate of one hundred thousand dollars, as given in our last annual report.

To aid them in defraying this expense, the directors have received from the treasurer of the Commonwealth, scrip or certificates of debt, to the amount of 50,000 dollars, so liberally granted by the last legislature, for the promotion of this important public improvement.

Little now remains for the entire completion of the work. The whole of this railroad (as well as the New Hampshire portion of the line) is laid in the most substantial manner, with a heavy iron rail of the most approved character, for stability, durability, and convenient use; and the rail track is, in other respects, equal to the best structures of the kind in New England. In the construction of the road bed itself, a new principle has been adopted, which the directors are confident will operate in a great measure to secure the rail track against one of the greatest evils to which railroads in this climate are exposed; the injurious effect of frost.

Total amount of capital paid in by stockholders,	$278,165 26
Massachusetts State scrip,	150,000 00
	428,165 26
There has been paid towards the construction of a bridge over Merrimac river and road,	86,923 13
The amount of income the past year is, from passenger train,	53,885 20
From merchandize train,	12,804 23
" transporting United States mail,	1,900 00
" rents, &c.	411 70
	$69,001 13
The amount expended the past year, exclusive of amount spent and charged to cost of road, for repairs of road,	3,609 48
For repairs of engines and cars,	3,931 84
" toll to B. and L. railroad corporation,	19,551 09
" fuel, oil, salaries and other miscellaneous expense,	16,230 26
	$43,322 67
The amount of dividends the past year is, being $6 per share on the stock, one dividend of two per cent. was made in April, the other of four per cent. in October,	18,000 00
Interest paid on State scrip,	5,000 00

All which is respectfully submitted,

Hobart Clark, En. Silsby, Sam'l A. Walker, Thos. West, Amos Abbot, *Directors.*

EIGHTH ANNUAL REPORT OF THE BOSTON AND PROVIDENCE RAILROAD CORPORATION.

To the Honorable Legislature of the Commonwealth of Massachusetts:

The directors of the Boston and Providence railroad corporation do hereby make their eighth annual report of their acts and doings, receipts and expenditures, as required by law.

During the past year they have settled their controversy with the Boston Water Power Cempany, and have also, under the authority given them by the act of the legislature of the tenth of April last, purchased of the Seekonk branch railroad company, their entire road, with its appurtenances, and all the rights, privileges and franchise to them belonging, and have filed in the secretary of State's office a duplicate of the deed or contract of sale.

They have also erected a large brick store house at the Boston depot, for the accommodation of the Taunton and Dedham branches, and have filled up a large piece of flats, and secured the same from the tides by a substantial stone wall. They have enlarged the machine shop, and erected an additional wood shed and a passenger house in Roxbury. They have also completed the second track to Roxbury, and have incurred a heavy expense in widening the road in various places, and in making drains and bank walls.

The whole amount of the capital of the corporation paid in, is		1,782,000 00
The whole amount of their expenditures the past year is as follows:		
For the purchase of the road and franchise of the Seekonk branch company, including their cars,		31,955 70
For construction of the main road, including sums paid for land and damages, erection of buildings, amount paid to Boston Water Power Company, completion of second track to Roxbury, and other permanent improvements,		$62,424 67
For repairs of road,		8,604 28
" repairs of engines and cars,		19,466 99
" amount paid to the Rhode Island railroad company, for the lease of their road, bridge, and depot, under contract sanctioned by the legislature of this Commonwealth,		6,468 10
For fuel, oil, salaries, wages, and all other miscellaneous expenses,		65,491 74
		$194,411 48
The amount received during the past year, is:		
For transportation of passengers,		234,237 42
" transportation of merchandize,		72,939 11
" transportation of mail,		3,000 00
" interest,	$3,495 74	
From which deduct the balance of interest against the company at the beginning of the year,	661 08	
Leaves the present balance of interest account in favor of the company,		2,834 66
For rents,		896 25
		$313,907 44
The amount divided the past year, is being in two dividends.		142,560 00

The first dividend was declared in Janurry, and the second in July last,

each being four per cent. on the amount of capital stock paid in, viz. $1,782,000.

All which is respectfully submitted,

Josiah Quincy, Jr., William Appleton, Joseph W. Revere, William Sturgis. *Directors.*

THE EIGHTH ANNUAL REPORT OF THE BOSTON AND WORCESTER RAILROAD CORPORATION.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts.

The Directors of the Boston and Worcester Railroad Corporation, respectfully submit the eighth annual Report of their proceedings, and of their receipts and expenditures.

Within the last year, the directors have, by agreement with the directors of the Western railroad corporation, united their road at Worcester with the said Western railroad, and established regular lines of transportation, for the conveyance of passengers and freight, over the whole of the said Boston and Worcester road, and such parts of the said Western road, as is completed and open for use; and in pursuance of said agreement, regular trains of passenger and freight cars, have been run between Boston and Springfield, since the opening of the Western railroad, with the exception of a few days, when the roads were obstructed by deep snows.

They have also agreed upon the terms of an arrangement, with the directors of the Norwich and Worcester railroad corporation, for establishing regular lines of transportation, for the conveyance of passengers and freight between Boston and Norwich, to be carried into operation, as soon as the said Norwich and Worcester railroad shall be completed. The rails are already laid on the whole of that road, with the exception of a distance of about two miles. The work on this part of the road was unfortunately interrupted in December, by a violent snow storm, at a time when it was hoped that with the continuance of two weeks more of mild weather, it might be finished, and the road opened for use during the winter. In consequence of this disappointment, the opening of the road was necessarily delayed, but there is no reason to doubt, that it will be completed early in the ensuing spring, when the arrangements, for establishing regular lines of communication over the whole of the two roads, will be carried into effect.

The directors have, within the last season, caused a second railway track to be laid down, on that part of the road which lies between Natick and Hopkinton, a distance of about seven miles. By establishing a double track for this distance, on the middle portion of the railroad, the upward and downward passenger and freight trains, which will be necessarily increased in number, in consequence of the opening of the Western and Norwich roads, will be enabled to pass one another with less delay and less liability to accident, than if required to meet, as heretofore, at one of the three stations at Framingham, Natick and Hopkinton. The work of laying this portion of a second track, is nearly completed, but in consequence of being retarded by an unexpected delay in the arrival of the iron from England, it was interrupted by the sudden approach of winter, before it was entirely finished.

Some further improvement in the construction of the road has been made during the past season, by enlarging the drains, and widening the deep cuts, for the purpose of rendering the rails more secure against the effects of the frost, and the drains against obstructions by slides of earth.

Some expenditures have also been made in enlarging the accommodations at some of the depot stations, and increasing the number of engines

and cars, in preparation for an enlarged amount of business, anticipated from the important extension of the lines of communication. For the purpose of meeting the expenditures for these objects, the stockholders voted, on the 1st day of November last, to increase the capital stock to $1,800,000 by the creation of 1000 additional shares, in the manner authorized by the charter all of which have been taken up at par.

The amount expended during the two last years, and charged to the account of construction, was	$137,791 43
The amount previously expended and charged to the same account, as by annual report of 1838, was	1,710,294 39
Making a total of	$1,848,085 82
From which deduct amount reserved from income and carried to reserved fund on account of decay and wear of road, engines, etc., beyond what is replaced by repairs and new work,	$48,830 00
Present valuation of road, land, depot, buildings, engines, cars, etc.	$1,799,255 82
The amount of income received during the past year was as follows:	
From fare of passengers,	$122,495 92
From freight, mail, etc.,	106,251 16
Rents, storage, etc.,	3,060 10
Total, not including a surplus of last year,	$231,807 18
The expenditures within the year, exclusive of the amount charged to the account of construction, were as follows:	
For repairs of engines and cars,	$25,198 46
Repairs of road,	18,035 09
All other expenses,	83,151 28
Total,	$126,384 83
The following dividends of profits were declared within the year, viz:	
July 1, 1839, 3½ per cent.	$59,500 00
Jan. 1, 1840, 3 per cent.	51,000 00
Total,	$110,500 00

All which is respectfully submitted,

Nathan Hale, David Henshaw, Eliphalet Williams, William Jackson, Daniel Denny, Nathaniel Hammond, William Sturgis, *Directors.*

MEMPHIS BRANCH RAILROAD AND STEAMBOAT COMPANY.

At the meeting of the stockholders of this company, held in Rome, on the 7th inst., the following gentlemen were appointed directors for the year 1840:—Messrs. D Mitchell, J. H. Lumpkin, J. Liddell, J. Rogers, G. W. Tuggle, T. Mills, and N. Yarbrough.

On the same day the board was organized by the election of D. Mitchell President *pro tem.*, and N. Yarbrough Secretary.

The Board of Directors have appointed Wm. Spencer Brown, Esq., principle engineer, with instructions to organize a party, and proceed forthwith with the survey, and location of the road.

Thus private enterprise will carry out what the State has so blindly neglected.

This railroad together with the Selma and Tennessee railroad, will form the most direct possible connection between the South Atlantic sea coast, and the western States—will be 100 miles shorter than the same connection *via* Ross' Landing—will strike the Tennessee river below all obstructions and at a point of the river navigable for *ten* months of the year.